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Fall assessment in subacute inpatient stroke rehabilitation using clinical characteristics and the most preferred stroke severity and outcome measures

Sinikka Tarvonen-Schröder[a,b], Tuuli Niemi[c], Saija Hurme[d] and Mari Koivisto[d]

[a]Neurocenter, Turku University Hospital, Turku, Finland; [b]Clinical Neurosciences, University of Turku, Turku, Finland; [c]Department of Expert Services, Turku University Hospital, Turku, Finland; [d]Department of Biostatistics, University of Turku, Turku, Finland

ABSTRACT

Introduction: No single tool is able to distinguish fallers from non-fallers. The aim of this study was to detect subacute stroke inpatients at higher risk for falls, predictors for the number of falls and near falls and the impact of these incidents on functional outcome.

Methods: An observational prospective cohort study comparing clinical differences between non-fallers, onetime and repeat fallers. Bivariate and multivariate Poisson regression analyses with length of stay as an offset variable were conducted.

Results: Fallers had mostly intermediate level of impairment and disability (NIHSS, FIM, mRS, the ICF minimal generic data set). The onetime fallers who were oldest, most disabled and most often institutionalised achieved the same functional improvement as the non-fallers, however, after significantly longer inpatient rehabilitation. The repeat fallers who were youngest and had the longest rehabilitation in-stay, achieved equal functioning as the non-fallers having faster motor gain and the greatest overall functional improvement compared to the other two subgroups.

Conclusions: Right hemispheric stroke, previous myocardial infarction and shorter time from stroke onset were independent predictors for the number of incidents. In the future, larger studies are recommended to investigate fall rate and different severities of incidents, falls and near falls separately.

Abbreviations: NIHSS: National Institutes of Health Stroke Scale; FIM: Functional Independence Measure; mRS: modified Rankin Scale; ICF: International Classification of Functioning, Disability and Health

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Fall; inpatient; near fall; rehabilitation; stroke; subacute

Introduction

Falls are one of the most common in-hospital adverse events among stroke survivors [1–3] and also a major problem at all stages after stroke [3]. Between 10.5% and 65% of stroke survivors fall at least once during hospitalisation for acute care and subacute inpatient rehabilitation [3–5], up to half of them repeatedly [3,6–10]. Injury rate varies [3] being up to one-third of all falls [11] or even more [10] with mostly mild injuries [3,4,11,12], fracture rate ranging from only 0.6% to 15%, which is similar to fracture rate for older population [3,4]. Even if post-stroke falls and their consequences are usually at the milder end of the continuum of all fall incidents, a considerable number of fall-related injuries still occur in stroke rehabilitation because these events are so common. In addition, people who confront falls are prone to experience activity limitations, increased dependence and fear of falling [13], which could interfere with the patient's recovery of functioning. In a review of 14 studies on post-stroke inpatient rehabilitation, a total of 28 associating factors were identified to predict falls. The most important risk factors were impaired balance, visuospatial hemi-neglect and impaired performance of daily activities [11]. The assumed multifactorial aetiology of falls and the reality that associating factors may alter make the issue more complex. The change in the odds for falls as time passes may also be independent of the baseline situation [14]. Post-stroke fall risk prediction models in acute and subacute inpatient settings most frequently highlight measures of hemi-inattention, while those predicting falls in chronic phase include a history of falls or near falls with balance measures [15–18]. So far, however, there is scarce and partly contradictory evidence on the possible differences between those with a single versus multiple incidents [6,19,20] and on the impact of these incidents on neurological recovery and outcomes in stroke rehabilitants [5,20].

It has been recommended, that different types of facilities should probably use different assessment scales [15]. Comparison between measures of stroke severity and functional measures [20,21] as well as between ICF components body functions and activities [22] has been suggested. As fall risk for stroke survivors has been thought to result from a

CONTACT Sinikka Tarvonen-Schröder sinikka.tarvonen-schroder@tyks.fi Neurocenter, Turku University Hospital, Turku, Finland; Clinical Neurosciences, University of Turku, PO Box 52, FIN-20521 Turku, Finland

Supplemental data for this article can be accessed here.

combination of many pre-existing factors (e.g. comorbidities, previous falls), stroke specific factors (e.g. strength, sensation, cognition, neglect), environmental (e.g. obstacles, lighting, slipperiness) and individual factors (e.g. age, sex, behaviour), there is no single tool to distinguish fallers from non-fallers [23–26]. Instead, using a variety of impairment measures (especially stroke-specific) and functional assessments may help to detect the patients at higher risk for falls [4,6].

The aim of this study was to investigate the utility of the routinely gathered clinical and functional data in the detection of increased fall risk by comparing stroke rehabilitants with no, one or repeated incidents. A unique set of the most widely applied and preferred instruments the National Institutes of Health Stroke Scale (NIHSS), the Functional Independence Measure (FIM) and the modified Rankin Scale (mRS) were used in addition to the ICF minimal generic data set covering functioning and health. The aim was also to investigate the impact of these incidents on functional recovery and outcome. Predictors for the number of incidents were determined, too. Our hypothesis was that routinely collected medical data could contain powerful information on fall risk for further procedures in our facility.

Patients and methods

Setting and timescales

On a university hospital inpatient rehabilitation ward, 195 consecutive subacute stroke patients were included in the study between August 2015 and September 2018. Fall prevention procedures including comprehensive electronic reporting of all fall and near fall events (time, place and description of the incident and possible injury) were revised in April 2015. All multidisciplinary team measures including risk factor evaluation, systematical and individually tailored assessment, management and monitoring, and environmental hazard elimination were enhanced during 2015–2016, however, without restricting activity levels. An intensive inpatient rehabilitation program consisted of combined coordinated meetings of a multidisciplinary team five days a week according to patients' individual needs in addition to constant rehabilitative nursing. The team encompassed registered nurses, a neurologist, a physiotherapist, an occupational therapist, a rehabilitation psychologist, a neuropsychologist, a speech and language therapist, a social worker, a rehabilitation planner, and when necessary, also other consultants.

Participants

The stroke patients were mostly referred to the neurological rehabilitation unit from the acute stroke unit of the same university hospital. Some patients had to wait after the acute stroke unit care on a general ward for stabilisation of their medical condition before intensive rehabilitation or because of lack of capacity of the rehabilitation unit. For admission to intensive multidisciplinary rehabilitation, patients had to be able to sit in a wheelchair for a minimum of 30 min. The level of mental abilities had to be adequate for active and intensive rehabilitation. All stroke rehabilitants admitted to the ward were included in the study except for rehabilitants aged under 18 years at the time of stroke onset, those with other current major medical or neurological disorders, psychotic condition or pre-stroke disability causing dependence on others, those with a history of previous stroke or brain injury without radiological findings, and if the rehabilitation was interrupted because of medical reasons. Part of the participants were also included in previous studies [27–31].

Measures

The rehabilitants were divided into three subgroups, non-fallers, onetime and repeat fallers and assessed clinically and functionally using the most common measures of stroke rehabilitation outcome. As there is no consensus on the battery of scales that should be used in fall assessment or clinical stroke practice, trials and research, we utilised a set of measures routinely used in our hospital, i.e. FIM, the most widely used generic measure of disability and outcome in rehabilitation hospitals [32], mRS, the most preferred and prevalent outcome measure after acute stroke [33,34], and NIHSS, which is a widely favoured severity measure and prognostic tool post stroke [35,36]. As there is insufficient and contradictory data on the possible differences between rehabilitants with a single versus multiple falls [6,19,20], they were investigated separately. Fall definitions vary [37]; in this study, all falls and serious near fall events reported by a staff member that would have led to a fall if not prevented (falls and 'near falls') were included.

Initial clinical data (e.g. ICD-10 diagnosis, date of diagnosis, initial and 24 h NIHSS score after possible thrombolysis and/or thrombectomy, comorbidities) were assessed in the course of routine clinical care and monitoring and collected from the hospital patient charts. The total number of comorbidities was counted, a procedure previously used to categorise comorbidities [38], and also the Charlson comorbidity index was calculated [39]. On the first day of rehabilitation, a physiotherapist assessed the level and safety of locomotion and possible ambulation of each rehabilitant and his or her need for assistive devices. An occupational therapist assessed the level of possible spatial neglect of each rehabilitant at admission using the Catherine Bergego Scale (CBS). Without delay, the data were converted from paper form to electronic format for medical records and for statistical analysis. A rehabilitation nurse, trained and accredited in accordance with Uniform Data System standards as a FIM® rater in cooperation with a physiotherapist (locomotion/stairs), assessed the level of dependence of each rehabilitant at admission and discharge using an electronic tool (FIM® version 5.2, Amherst, NC). A neurologist assessed stroke severity at admission using the NIHSS scale and functioning at discharge using mRS and the ICF minimal generic data set. The rehabilitants or their significant others filled in a questionnaire on demographic data including age, gender (identified as male or female), marital status/cohabiting, years of education, studying/working status and signed an informed consent.

A fall was defined as an event which resulted in a person coming to rest inadvertently on the ground or another level and other than a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis such as stroke or an epileptic seizure [16]. A near fall was defined as a major stumble event or loss of balance reported by a staff member that would have resulted in a fall if not assistance by another person or external circumstances contributed to prevent the actual fall. Differing data collection methods (prospective vs. retrospective, e.g. trauma registers, medical records, incident reports, patient recall) inevitably lead to variable data on falls. Our intension was to capture and register as flawlessly as possible the whole continuum of these incidents, attended and unattended including all severities and occasions. The term faller/non-faller is used in this article to denote all patients with/without incidents, falls or near falls or both. The number of incidents is described as no falls, one or repeated (≥2) falls.

NIHSS was developed to measure neurologic outcome and recovery in patients with stroke. It is a 15-item scale of key components of a standard neurological examination used to assess stroke severity and neurologic impairment on the levels of consciousness, language, neglect, visual-field loss, extraocular movement, motor strength, ataxia, dysarthria and sensory loss. Ratings for each item are scored with 3–5 grades with 0 as normal. The total score varies from 0 to 42 ('normal functioning' – 'coma'); total scores 1–4 mean mild, 5–15 moderate, 16–20 severe and 21–42 very severe stroke [40]. In the present study, the items with significant between-group differences are shown in Supplementary Table 1. A trained observer rates the patient's ability to answer questions and perform activities in less than 10 min. NIHSS is easy to apply, sensitive and one of the most reliable and valid instruments of clinical measurement in stroke [41,42]. As the population admitted to intensive subacute stroke rehabilitation does not include the most severe stroke survivors, the potential ceiling effect [43] is not a concern.

FIM® (http://udsmr.org) has been designed to measure physical and cognitive disability and dependence in 18 items (four motor and two cognitive domains) on a scale 1–7 ('no activity' or 'total dependence' – 'complete independence') [44,45]. The items and domains are presented in Table 1 and in Supplementary Table 2. The total score ranges from 18 to 126, motor sub-score from 13 to 91, and cognitive sub-score from 5 to 35. For a trained professional, rating the items electronically takes about 60 min. FIM is valid and reliable [46–48] for use in stroke and it is sensitive to change, especially the motor subscale [49,50]. FIM cut-off score for community discharge after subacute stroke rehabilitation has found to be 78 in a large registry study [51], and for autonomy in everyday life and independence of social and familial assistance the threshold has been settled at 115 [52]. FIM efficiency is the mean change in FIM score per day. FIM effectiveness is FIM at discharge minus FIM on admission × 100%. Corrected FIM effectiveness is calculated as (FIM at discharge – FIM on admission)/(A – FIM on admission). A is generally taken to be 126 points for overall FIM score and 91 for motor FIM sub-score. The corrected version of FIM effectiveness corrects the ceiling effect present in FIM gain. FIM motor effectiveness with advanced correction corrects for both floor and ceiling effects and is calculated so that motor FIM effectiveness is approximately 0.65, whereupon A varies, being 42, 64, 79, 83, 87, 89 or 91 points when the admission FIM motor sub-score is 13–18, 19–24, 25–30, 31–36, 37–42, 43–48 or 49–90 points, respectively [53].

CBS is a measure of functional neglect in spontaneous behaviour. It is based on direct observation of 10 real-life situations, i.e. grooming, dressing, eating, mouth cleaning, gaze orientation, knowledge of limbs, auditory attention, moving (collisions), spatial orientation and finding personal belongings. It captures mild neglect better than traditional paper-pencil tests. The total score 1–10 means mild, 11–20 moderate and 21–30 severe neglect. The CBS has been found reliable and valid, and the 10 items define a homogeneous construct [54]. Assessment time varies depending on the patient being usually from 30 to 60 min.

MRS is a very simple and fast to use tool of disability or dependence encompassing seven levels: 0: independent patients with no residual symptoms, 1: no significant disability despite symptoms, able to carry out all previous duties and activities; 2: slight disability, unable to carry out all previous activities, but able to look after own affairs without assistance; 3: moderate disability, requiring some help but able to walk independently; 4: moderately severe disability, unable to walk and attend to bodily needs without assistance; 5: severe disability, bedridden, incontinent and requiring constant nursing care and attention; 6: death. This rough measure incorporates the ICF components body functions, activity and participation. Thus, it lacks specificity and instead describes overall outcome. MRS has substantial clinical threshold between each point in the scale and the difference between one or more grades is clinically meaningful [40,55]. Hence, responsiveness of mRS is poor during short-term intervals. It has been the preferred outcome measure for acute stroke trial at three months after stroke onset or later [34] and multiple types of evidence attest to the validity and reliability of the mRS [40,56].

The WHO minimal generic data set covering functioning and health consists of seven ICF categories: energy and drive functions, emotional functions, sensation of pain, carrying out daily routine, walking, moving around and remunerative employment. Generic means that this scale is applicable to all people despite their health conditions. Minimal means that the scale consists of the least number of domains of functioning that can be used to explain significant differences between people with health issues. Each of the items is rated according to a five-point Likert-type scale. The scoring is from 0 to 4 where 0 means no (0–4%), 1 means mild (5–24%), 2 means moderate (25–49%), 3 means severe (50–95%) and 4 means extreme or complete (96–100%) difficulty in this specific body function or activity. The sum score ranges from 0 to 28. For an experienced assessor, documentation of the grading takes a couple of minutes after multidisciplinary assessment. In subacute stroke, the WHO

Table 1. Between-group differences in FIM change during rehabilitation and FIM change per day[a].

Variables: median (range)	Total change										Change per day									
					p, difference between medians (95% confidence limits)										p, difference between media (95% confidence limits)					
	Non-fallers (n = 146)	Onetime fallers (n = 28)	Repeat fallers (n = 21)	p	No vs. one		No vs. repeat		One vs. repeat		Non-fallers	Onetime fallers	Repeat fallers	p	No vs. one		No vs. repeat		One vs. repeat	
FIM total score	5 (−16 to 48)	9.5 (−13 to 43)	18 (−3 to 62)	.0001	.29	4 (−1 to 9)	.0003	13 (8–18)	.15	10 (0–19)	0.25 (−0.5 to 1.6)	0.26 (−1.0 to 1.3)	0.38 (−0.06 to 1.6)	.05	1.0	0.07 (−0.1 to 0.2)	.05	0.2 (0.04–0.3)	.65	0.1 (0.08–0.3)
Motor subscore	3 (−19 to 38)	9 (−10 to 38)	18 (0–49)	.0001	.05	3 (1–9)	.0003	13 (7–18)	.16	8 (0–16)	0.16 (−0.9 to 1.4)	0.23 (−0.6 to 1.2)	0.33 (0.0–1.2)	.006	.29	0.09 (−0.02 to 0.2)	.008	0.2 (0.08–0.3)	.81	0.1 (0.08–0.3)
Cognitive subscore	0 (−7 to 15)	1 (−4 to 11)	1 (−3 to 15)	.12							0.0 (−0.3 to 0.9)	0.02 (−0.3 to 0.3)	0.03 (−0.1 to 0.4)	.43						
Grade 1–7	0 (−1 to 3)	1 (−1 to 3)	1 (0–4)	.0001	.20	0 (0–1)	.0003	1 (1–1)	.30	1 (0–1)	0.0 (−0.1 to 0.1)	0.02 (−0.1 to 0.1)	0.02 (0.0–0.1)	.009	.50	0 (0–0.02)	.007	0.02 (0.001–0.02)	1.0	0.004 (−0.008 to 0.02)
Self-care																				
Eating	0 (0–2)	0 (−1 to 5)	1 (0–5)	.002	.48	0 (0–0)	.002	0 (0–1)	.35	0 (0–1)	0.0 (0.0–0.1)	0.0 (−0.01 to 0.2)	0.02 (0.0–0.1)	.02	.47	0 (0–0)	.02	0 (0–0.02)	1.0	0 (0–0.02)
Grooming	0 (−3 to 4)	0 (−1 to 4)	1 (−1 to 5)	.05	.49	0 (0–0)	.08	0 (0–1)	1.0	0 (0–1)	0.0 (−0.1 to 0.3)	0.0 (−0.1 to 0.2)	0.02 (−0.03 to 0.1)	.24						
Bathing	0 (−1 to 4)	0 (−2 to 3)	1 (0–4)	.02	1.00	0 (0–0)	.01	1 (0–1)	.15	1 (0–1)	0.0 (−0.1 to 0.4)	0.0 (−0.2 to 0.1)	0.02 (0.0–0.1)	.14						
Dressing upper body	0 (−1 to 4)	1 (−1 to 5)	1 (0–5)	.001	.49	0 (0–1)	.0009	1 (0–1)	.34	1 (0–1)	0.0 (−0.1 to 0.3)	0.02 (−0.1 to 0.1)	0.02 (0.0–0.1)	.05	.84	0 (0–0.01)	.04	0.02 (0–0.02)	1.0	0.002 (−0.01 to 0.02)
Dressing lower body	0 (−2 to 4)	1 (−1 to 4)	2 (0–6)	.0001	.53	0 (0–1)	.0003	2 (1–2)	.03	1 (0–2)	0.0 (−0.3 to 0.2)	0.02 (−0.1 to 0.1)	0.05 (0.0–0.1)	.007	1.0	0 (0–0.02)	.004	0.02 (0.007–0.05)	.21	0.02 (0–0.05)
Toileting	0 (−2 to 6)	0 (−2 to 5)	2 (−1 to 6)	.0002	.16	0 (0–1)	.0003	1 (1–2)	.80	1 (0–2)	0.0 (−0.2 to 0.3)	0.0 (−0.2 to 0.2)	0.05 (−0.05 to 0.2)	.004	.28	0 (0–0.02)	.004	0.03 (0.004–0.05)	1.0	0.01 (−0.02 to 0.04)
Sphincter control																				
Bladder	0 (−5 to 6)	0 (−1 to 6)	1 (−1 to 6)	.0009	.44	0 (0–0)	.0006	1 (0–2)	.35	1 (0–2)	0.0 (−0.2 to 0.2)	0.0 (−0.04 to 0.1)	0.03 (−0.03 to 0.2)	.003	.51	0 (0–0)	.002	0.02 (0–0.03)	.45	0.01 (0–0.04)
Bowel	0 (−4 to 6)	0 (−1 to 4)	0 (−5 to 6)	.58							0.0 (−0.4 to 0.4)	0.0 (−0.1 to 0.1)	0.0 (−0.24 to 0.2)	.74						
Transfers																				
Bed, chair, whealchair	0 (−1 to 4)	1 (0–4)	2 (0–6)	.0001	.002	1 (0–1)	.0003	1 (1–2)	.55	1 (0–1)	0.0 (−0.1 to 0.2)	0.04 (0.0–0.1)	0.04 (0.0–0.1)	.0001	.004	0.02 (0–0.04)	.0003	0.03 (0.02–0.04)	1.0	0 (−0.02 to 0.02)
Toilet	0 (−1 to 3)	1 (0–4)	2 (0–6)	.0001	.003	1 (0–1)	.0003	1 (1–2)	.41	1 (0–1)	0.0 (−0.1 to 0.2)	0.04 (0.0–0.1)	0.05 (0.0–0.1)	.0001	.007	0.01 (0–0.04)	.0003	0.03 (0.02–0.05)	1.0	0.004 (−0.01 to 0.03)
Tub, shower	0 (−1 to 5)	1 (−6 to 4)	2 (−1 to 6)	.0001	.14	0 (0–1)	.0003	1 (1–2)	.19	1 (0–2)	0.0 (−0.1 to 0.2)	0.03 (−0.4 to 0.1)	0.04 (−0.02 to 0.1)	.005	.42	0 (0–0.02)	.005	0.02 (0.01–0.04)	.85	0.009 (−0.007 to 0.03)
Locomotion																				
Walk	0 (−1 to 6)	0 (−5 to 7)	0 (0–6)	.01	.67	0 (0–0)	.008	0 (0–1)	.56	0 (0–1)	0.0 (−0.1 to 0.2)	0.0 (−0.3 to 0.2)	0.0 (0.0–0.2)	.02	.75	0 (0–0)	.002	0 (0–0.008)	1.0	0 (0–0.04)
Wheelchair	0 (−5 to 5)	0 (−6 to 2)	0 (−6 to 3)	.78							0.0 (−0.1 to 0.2)	0.0 (−0.2 to 0.1)	0.0 (−0.2 to 0.01)	.72						
Both	0 (−5 to 3)	0 (−4 to 0)	0 (−5 to 0)	.03	.48	0 (0–0)	.04	0 (0–0)	1.0	0 (0–0)	0.0 (−0.1 to 0.1)	0.0 (−0.2 to 0.0)	0.0 (−0.13 to 0.0)	.03	.47	0 (0–0)	.04	0 (0–0)	1.0	0 (0–0)
Main locomotion	0 (−1 to 5)	0 (−3 to 5)	1 (0–5)	.13							0.0 (−0.1 to 0.2)	0.0 (−0.2 to 0.2)	0.02 (0.0–0.1)	.39						
Stairs	0 (−2 to 6)	0 (0–5)	2 (0–5)	.0008	.51	0 (0–0)	.0009	2 (0–2)	.10	1 (0–2)	0.0 (−0.3 to 0.4)	0.0 (0.0–0.2)	0.04 (0.0–0.2)	.02	.87	0 (0–0)	.02	0.03 (0–0.04)	.34	0.01 (0–0.04)
Communication																				
Main comprehension	0 (−7 to 7)	0 (−1 to 2)	0 (0–6)	.07							0.0 (−0.6 to 0.2)	0.0 (−0.1 to 0.06)	0.0 (0.0–0.1)	.14						
Main expression	0 (−3 to 3)	0 (−3 to 4)	0 (−1 to 4)	.81							0.0 (−0.1 to 0.2)	0.0 (−0.3 to 0.2)	0.0 (−0.01 to 0.10)	.68						
Social cognition																				
Social interaction	0 (−2 to 4)	0 (−2 to 6)	0 (−1 to 3)	.70							0.0 (−0.1 to 0.2)	0.0 (−0.1 to 0.1)	0.0 (−0.02 to 0.1)	.66						
Problem solving	0 (−3 to 5)	0 (−2 to 3)	1 (−1 to 5)	.16							0.0 (−0.3 to 0.2)	0.0 (−0.1 to 0.1)	0.02 (−0.03 to 0.1)	.40						
Memory	0 (−3 to 4)	0 (−3 to 5)	0 (−2 to 6)	.08							0.0 (−0.2 to 0.3)	0.0 (−0.2 to 0.1)	0.0 (−0.04 to 0.1)	.24						

FIM: Functional Independence Measure.
[a]The Kruskal–Wallis test with Bonferroni's correction in pairwise comparisons. Difference on Hodges–Lehmann-estimate for median difference.

Table 2. Bivariate associations between the number of incidents and factors potentially associated with incidents using length of stay as an offset variable.

Variables ($n = 195$)	IRR	95% CI	p
Baseline variables (acute)			
24 hour NIHSS score (0–42)	0.9889	0.9606, 1.0181	.45
Severity of paresis (NIHSS 0–16)	0.9624	0.9098, 1.0182	.18
DNR	1.0269	0.5135, 2.0534	.94
Variables at admission			
Age	0.9934	0.9758, 1.0110	.45
Education	0.9742	0.9174, 1.0346	.40
Time from stroke onset	0.9941	0.9880, 1.0002	.06
Diagnosis			.09
Subarachnoid haemorrhage	Reference		
Intracerebral haemorrhage	3.3865	0.8126, 14.1129	.09
Infarction	2.4577	0.5966, 10.1243	.21
NIHSS score (0–42)	1.0168	0.9775, 1.0575	.41
NIHSS score			.12
Mild (1–4)	Reference		
Moderate (5–15)	1.4973	0.8189, 2.7349	.19
Severe or very severe (≥16)	0.8626	0.3864, 1.9254	.72
FIM total score (18–126)	0.9935	0.9856, 1.0015	.11
FIM motor sub-score (13–91)	0.9916	0.9820, 1.0012	.09
FIM bladder score (1–7)	0.9676	0.8909, 1.0509	.43
Severity of neglect (CBS 0–29)	1.0255	0.9997, 1.0519	.05
Severity of neglect (CBS 1–29) ($n = 135$)			.14
Mild (1–10)	Reference		
Moderate (11–20)	1.6926	1.0051, 2.8505	.05
Severe (21–30)	1.3485	0.7376, 2.4653	.33
Localisation			.06
Right hemisphere	Reference		
Left hemisphere	0.5199	0.3198, 0.8454	.008
Both sides	0.6175	0.2876, 1.3258	.22
Posterior circulation	0.5797	0.2584, 1.3993	.19
Right hemispheric stroke	1.8366	1.1862, 2.8437	.006
Left hemispheric stroke	0.6202	0.3938, 0.9768	.04
Side of paresis ($n = 190$)[a]			.04
No	Reference		
Right	2.2783	1.1767, 4.4112	.01
Left	1.7466	0.9086, 3.3568	.09
Presence of paresis	1.9097	1.0345, 3.5253	.04
Severity of paresis (NIHSS 0–16)	1.0234	0.9561, 1.0955	.50
Measures at discharge			
FIM motor effectiveness	1.0002	1.0000, 1.0003	.02
FIM motor efficiency	1.9982	0.9687, 4.1221	.06
Corrected FIM motor effectiveness	1.5003	0.7410, 3.0377	.26
FIM motor effectiveness with advanced correction	1.0035	0.9967, 1.0105	.32
Corrected FIM total effectiveness	1.6569	0.7351, 3.7346	.22
FIM total score (18–126)	0.9980	0.9898, 1.0063	.64
FIM motor sub-score (13–91)	0.9977	0.9875, 1.0080	.66
MRS (2–5)	1.0993	0.8202, 1.4734	.53
ICF minimal generic data set score (0–28)	1.0292	0.9824, 1.0783	.22
ICF minimal generic data set score			.02
Mild (1–7)	Reference		
Moderate (8–14)	1.7971	0.4265, 7.5714	.42
Severe (15–21)	3.1088	0.7565, 12.7762	.11
Very severe (22–28)	1.556	0.1931, 6.9155	.87
Discharge disposition			.19
Home without service	Reference		
Home with service	1.1537	0.5444, 2.4449	.71
Institution	1.6530	0.8070, 3.3860	.17
Disease severity and comorbidities			
DNR at admission	1.3042	0.6286, 2.7062	.48
Cardiovascular disease	1.3848	0.7905, 2.4259	.26
Myocardial infarction	1.8932	1.0643, 3.3678	.03
Number of comorbidities	1.2399	0.9936, 1.5472	.06
Charlson comorbidity index	1.1603	0.8934, 1.5070	.26

IRR: incidence rate ratio; CI: confidence limits; NIHSS: National Institutes of Health Stroke Scale; CBS: Catherine Bergego Scale; FIM: Functional Independence Measure; MRS: modified Rankin Scale; DNR: decision not to resuscitate.
[a]Those with paresis on both sides were excluded.

minimal generic data set has been found to correlate very strongly with FIM and mRS and strongly with the preceding NIHSS scores [27]. It is the briefest ICF core set and has been suggested to be regularly used as a starting point to address comparability of data across studies and nations [57].

Statistical analysis

Categorical variables were described using frequencies and percent and for continuous variables medians with range of values were used. The comparisons between the three sub-groups were carried out using chi-squared test for categorical variables, or Fisher's exact test in the case of small cell frequencies. The Bonferroni correction was used for pairwise comparisons. For normally distributed continuous variables (corrected FIM effectiveness, the ICF minimal generic data set sum), the comparisons between the three groups were carried out using one-way analysis of variance and in pairwise comparisons the Tukey–Kramer method was used to correct the p values. If the distribution of an outcome variable was not normal (all other continuous variables), the non-parametric Kruskal–Wallis test was used and for pairwise comparisons Mann–Whitney's U-test with Bonferroni's correction. One-way analysis of variance results are reported with p values, estimated difference between groups with 95% confidence interval. Non-parametric test results are reported with p values and Hodges–Lehmann-estimate for median difference with 95% confidence intervals. Associations between the number of falls and near falls as a dependent (outcome) variable and variables potentially associated with these incidents (see these independent variables itemised in Table 2) were investigated with the Poisson regression using length of stay as an offset variable. With specific motivations, factors found to have a significant or close to significant ($p<.15$) bivariate association with the outcome variable (number of incidents) were included as independent variables (see eight independent variables itemised in Table 3) in the Poisson regression model with length of stay as an offset variable. Possible multicollinearity was checked; correlation coefficient ≥0.8 was considered a sign of multicollinearity. P values below .05 (two-tailed) were considered statistically significant. Statistical analyses were performed using SAS 9.4 for Windows (SAS Institute Inc., Cary, NC).

Results

Of the 195 rehabilitants, 49 (25.1%) had falls or near fall incidents, 28 once and 21 repeatedly (13 patients had two, and eight had from three to five incidents, Table 4). Altogether, 81 incidents were reported (51 falls and 30 near falls). Twenty-eight participants had only falls (eight repeatedly), 12 only near falls (four repeatedly) and nine both falls and near falls. The number of participants who actually fell was 37 (19.0%). The incidence of all events (falls and near falls) during the three years investigated was 14.8/1000 patient days and of the actual falls 9.3/1000 patient days and it was found to decrease during the study from 17.7/1000 patient days in year 2016, to 15.7, and 12.7 in years 2017 and 2018, respectively.

Falls did not cause any major injuries such as fractures, 11 rehabilitants got minor injuries, of them six superficial bruises and five transient pain without any visible signs. Near fall events did not result in any injuries. Thirty-eight incidents occurred during transfer from or to the wheelchair, 17 during standing or walking, nine when getting up in order to walk, six when gliding from the seat, six when reaching something, two when sitting down after walking, three patients were falling from bed and one was climbing over the rails. Forty-one events happened in a patient room, 21 in toilet, 17 in other sites of the ward and one outdoors. All but three incidents occurred daytime.

Demographic data are shown in Table 4. Both onetime and repeat fallers had higher stroke, paresis and neglect severity on admission than the non-fallers and the onetime fallers had more co-morbidities than the other two subgroups (Table 5, Supplementary Table 1). The distribution of fallers in different stroke severities (NIHSS) was, however nonlinear: in rehabilitants with mild, moderate, severe and very severe stroke 13%, 34%, 36% and 0%, respectively, and in those with no, mild, moderate, severe and total leg paresis (left or right) 5%, 38%, 60%, 24% and 27%, respectively. None of those with NIHSS >20, NIHSS arm and leg motor impairment >8 or paresis on both sides had incidents.

FIM total score (Table 5), motor sub-score and most single item scores (Supplementary Table 2) showed significantly greater dependence in onetime and repeat fallers than in non-fallers at admission, but only in onetime fallers at discharge. Compared to the other two subgroups, the repeat fallers had significantly higher corrected total FIM effectiveness (Table 5) and their FIM efficiency score was highest being significantly higher than in the non-fallers (Table 1). In closer analysis, the distribution of fallers showed nonlinearity in FIM grades 1–7 (admission – discharge): 18–0%, 40–50%, 47–35%, 30–26%, 2–47%, 0–13% and 0–0%, respectively. Twelve percent ($n = 12/99$) of those ambulatory at admission, 37% ($n = 32/86$) of those sedentary and 50% (5/10) of those moving both ways had future incidents. Of those transforming from sedentary (admission FIM wheeling score 5 and 6) to walking status (admission FIM walking score 1), 50%, 44% and 80% had incidents, respectively. None of the rehabilitants with an admission score of 5–7 in stairs had future incidents while 88% of the fallers had FIM score 1 in stairs. When considering the admission FIM transfer (chair, toilet, bath) items, the highest proportion of future fallers was in FIM grade 2 (54–62%), other grades: 1 (32–26%), 3 (40–44%), 4 (42–44%), 5 (31–37%), 6 (18–10%) and 7 (3–4%). Corresponding figures in admission FIM main locomotion (ambulatory or sedentary or both) scores 2–5 varied between 33 and 44%, while in scores 1, 6 and 7 the figures were 25%, 24% and 0%, respectively.

At discharge, also the ICF minimal generic data set and mRS showed higher disability in the onetime fallers than in the non-fallers, but no significant difference was found between the repeat fallers and the non-fallers. The minimal generic data set sum score 15–21/28 was most significantly associated with the number of incidents (Table 2). In all single ICF activity items, disability was higher in onetime fallers than in non-fallers (Pearson's chi-square test): walking (p=.0009), moving around (p=.0004) and doing housework (p=.03). In these items, a nonlinear distribution of fallers (onetime and repeat) was found in qualifier categories 0–4, e.g. in walking 0%, 12%, 27%, 41% and 25%, respectively (the repeat fallers having on average lower qualifiers than the one-time fallers). Nonlinearity in the distribution of fallers (onetime and repeat) in mRS grades 2–5 was also found: 8.2%, 20.4%, 71.4% and 0%, respectively (Table 5).

Table 2 demonstrates bivariate associations between the number of incidents as dependent (outcome) variable and factors potentially associated with incidents as independent

Table 3. Results of multivariate Poisson regression analysis[a].

Variables	IRR	95% CI	p
Time after stroke onset	0.9929	0.9862, 0.9996	**.04**
Diagnosis			.45
Subarachnoid haemorrhage	Reference		
Intracerebral haemorrhage	1.8884	0.4180, 8.5318	.41
Infarction	1.4387	0.3314, 6.2463	.63
Severity of neglect (CBS)	0.9994	0.9695, 1.0302	.97
Stroke localisation			**.02**
Right hemisphere	Reference		
Left hemisphere	0.4491	0.2576, 0.7830	**.005**
Both sides	1.0562	0.4620, 2.4149	.90
Posterior circulation	1.0471	0.4290, 2.5558	.92
Presence of paresis	1.9481	0.9546, 3.9755	.07
Total number of comorbidities	1.0484	0.8012, 1.3719	.73
History of myocardial infarction	2.7231	1.2830, 5.7795	**.009**
FIM motor effectiveness	1.0001	0.9999, 1.0003	.21

IRR: incidence rate ratio; CI: confidence limits; FIM: Functional Independence Measure; CBS: Catherine Bergego Scale.
Bold values represent significant p values below .05.
[a]With specific motivations, explicative variables significant or close to significant in bivariate analysis (p<.15) as independent variables and the number of incidents as dependent (outcome) variable, length of stay as an offset variable.

Table 4. Demographic data of the participants ($n = 195$) with significant between-group differences[a].

Variables: median (IQR) or n (%)	Non-fallers ($n = 146$)	Onetime fallers ($n = 28$)	Repeat fallers[b] ($n = 21$)	p	No vs. one	No vs. repeat	One vs. repeat
Demographic data							
Age (years)	64.6 (55.2, 71.8)	68.4 (62.4, 74.2)	57.7 (48.5, 65.3)	.01	.22	.14	.01
Male gender	73 (50.0)	18 (64.3)	14 (66.7)	ns			
Education (years)	11 (9,14)	8 (8, 11)	12 (10, 15)	.005	.01	.62	.01
Still working	55 (37.7)	6 (21.4)	10 (47.6)	ns			
Cohabiting	92 (63.0)	17 (60.7)	11 (52.4)	ns			
Time from stroke on admission (days)	43.0 (23.0, 73.0)	36.5 (25.5, 78.0)	30.0 (23.0, 45.0)	ns			
Length of stay in rehabilitation (days)	19.0 (11.0, 33.0)	30.5 (17.5, 39.0)	50.0 (34.0, 57.0)	<.0001	.02	.0003	.005
Time from stroke at the first incident	–	61.5 (36.5, 83.5)	44.0 (31.0, 54.0)				
Time from admission at the first incident	–	11.5 (3.0, 18.5)	3 (1.0, 17.0)				
Time from admission at the second incident	–	–	21 (8.0, 33.0)				

IQR: interquartile range.
[a]The Kruskal–Wallis test with Bonferroni's correction in pairwise comparisons.
[b]Thirteen fallers had 2 incidents, six had 3, one had 4 and one 5 incidents.

Table 5. Clinical data of the participants ($n = 195$) with between-group differences[a].

Variables	Non-fallers	Onetime fallers	Repeat fallers		*p*, difference between medians (95% confidence limits)		
Median (range) or *n* (%)	($n = 146$)	($n = 28$)	($n = 21$)	*p*	No vs. one	No vs. repeat	One vs. repeat
Stroke characteristics							
Stroke type							
Subarachnoid haemorrhage	16 (11.0)	0 (0)	1 (4.8)	.004	.003	.72	.95
Intracerebral haemorrhage	31 (21.2)	15 (53.6)	8 (38.1)				
Infarction	99 (67.8)	13 (46.4)	12 (57.1)				
Stroke localisation							
Left hemisphere	68 (46.6)	12 (42.9)	8 (38.1)	.01	.004	1.0	.57
Right hemisphere	33 (22.6)	15 (55.6)	8 (38.1)				
Both sides	27 (18.5)	0 (0)	2 (9.5)				
Posterior circulation	18 (12.3)	1 (3.6)	3 (14.3)				
Right hemispheric stroke	33 (22.6)	15 (53.6)	8 (38.1)	.002	0.002	.37	.85
Left hemispheric stroke	68 (46.6)	12 (42.9)	8 (38.1)	.01	1.0	1.0	1.0
Stroke severity: 24 h NIHSS							
Mild	27 (18.5)	1 (3.6)	2 (9.5)	.32			
Moderate	60 (41.1)	13 (46.4)	9 (42.9)				
Severe	33 (22.6)	13 (46.4)	8 (38.1)				
Very severe	26 (17.8)	1 (3.6)	2 (9.5)				
Stroke severity: NIHSS at admission							
Mild	67 (45.9)	6 (21.4)	4 (19.0)	.02	.02	.04	1.0
Moderate	56 (38.4)	15 (53.6)	14 (66.7)				
Severe	18 (12.3)	7 (25.0)	3 (14.3)				
Very severe	5 (3.4)	0 (0)	0 (0)				
Clinical characteristics at admission							
Severity of paresis (NIHSS)							
0	67 (45.9)	2 (7.1)	4 (19.1)	.02	.005	.04	1.0
1–4	41 (28.1)	17 (60.7)	7 (33.3)				
5–8	35 (24.0)	9 (32.1)	10 (47.6)				
>8	3 (2.0)	0 (0)	0 (0)				
Side of paresis							
No	67 (45.9)	2 (7.2)	4 (19.0)	.0004	.0003	.14	1.0
Only left	26 (17.8)	13 (46.4)	8 (38.1)				
Only right	48 (32.9)	13 (46.4)	9 (42.9)				
Both	5 (3.4)	0 (0)	0 (0)				
Left hemiparesis	31 (21.2)	13 (46.4)	8 (38.1)	.01	.001	.26	1.0
Right hemiparesis	53 (36.3)	13 (46.4)	9 (42.9)	.55	.93	1.0	1.0
Sensory impairment							
No	70 (47.9)	11 (39.3)	8 (38.1)	.44			
Partial	61 (41.8)	12 (42.9)	12 (57.1)				
Severe	15 (10.3)	5 (17.8)	1 (4.8)				
Presence of neglect (Pearson's chi-square test)	93 (63.7)	27 (96.4)	18 (85.7)	.0006	.0006	.14	.90
Severity of neglect (CBS) (Kruskal–Wallis test)	2 (0–30)	7 (0–29)	9 (0–26)	.0001	.0009, 3 (1–6)	.02, 4 (1–7)	1.0, 0 (−3.5 to 4)
Side of neglect							
Right	54 (58.1)	16 (59.3)	9 (50.0)	.71			
Left	36 (38.7)	11 (40.7)	9 (50.0)				
Both	3 (3.2)	0 (0)	0 (0)				
Presence of apraxia (Pearson's chi-square test)	92 (63.0)	15 (53.6)	17 (81.0)	.14			
Aphasia							
No	72 (49.7)	17 (60.7)	13 (61.9)	.33			
Mild to moderate	42 (29.0)	5 (17.9)	6 (28.6)				
Severe	23 (15.9)	3 (10.7)	0 (0)				

(continued)

Table 5. Continued.

Variables Median (range) or *n* (%)	Non-fallers ($n = 146$)	Onetime fallers ($n = 28$)	Repeat fallers ($n = 21$)	*p*	*p*, difference between medians (95% confidence limits) No vs. one	 No vs. repeat	 One vs. repeat
Global	8 (5.5)	3 (10.7)	2 (9.5)				
Presence of dysphagia	22 (15.1)	8 (28.6)	2 (10.0)	.15			
Decision not to resuscitate	9 (6.2)	6 (21.4)	1 (4.8)	.02	.05	1.0	.64
Comorbidities							
Number of comorbidities							
0	24 (16.4)	3 (10.7)	1 (4.8)	.02	.03	.78	.27
1–2	106 (72.6)	15 (53.6)	18 (85.7)				
3–4	16 (11.0)	10 (35.7)	2 (9.5)				
Charlson index							
0	106 (72.6)	12 (42.9)	14 (66.7)	.02	.01	1.0	.55
1	32 (21.9)	10 (35.7)	7 (33.3)				
≥2	8 (5.48)	6 (21.4)	0 (0)				
Hypertension (Pearson's chi-square test)	102 (69.9)	21/ (75.0)	17 (80.9)	.53			
Diabetes	21 (14.4)	7 (25.0)	2 (9.5)	.26			
Cardiovascular disease	14 (9.6)	9 (32.1)	2 (9.5)	.004	.01	1.0	.26
Myocardial infarction	8 (5.5)	8 (28.6)	2 (11.1)	.0006	.003	1.0	.47
Heart failure	10 (6.8)	4 (14.3)	1 (4.8)	.35			
Atrial fibrillation (Pearson's chi-square test)	42 (28.8)	9 (32.1)	6 (28.6)	.94			
Dementia	1 (0.7)	2 (7.1)	0 (0)	.03	.20	1.0	1.0
Depression	12 (8.2)	3 (10.7)	2 (11.8)	.76			
Data at discharge							
Corrected FIM total effectiveness (ANOVA)	0.21 (−0.4 to 1.0)	0.21 (−0.2 to 0.8)	0.60 (−0.05 to 0.9)	.004	.91, 0.02 −0.09 to 0.1)	0.004, −0.2 (−0.3 to −0.08)	0.01, −0.2 (−0.4 to −0.08)
FIM total at admission	99.5 (18–126)	69.5 (30–112)	74 (40–106)	.0001	.0006	.01	1.00
FIM total at discharge	114 (18–126)	90 (39–116)	105 (52–124)	.0003	.0006	.43	.04
mRS 2 (Pearson's chi-square test)	37 (25.3)	0 (0)	4 (19.0)	.0002	.0003	.20	.22
3	55 (37.7)	6 (21.4)	4 (19.0)				
4	48 (32.9)	22 (78.6)	13 (62.0)				
5	6 (4.1)	0 (0)	0 (0)				
The WHO minimal generic data set sum (ANOVA)	12 (4–27)	16 (8–22)	15 (4–26)	.007	.01, −3 (−4.9 to −1.0)	0.26, −1.8 (−4.0 to 0.5)	0.67, 1.2 (−1.6 to 4.0)
Discharge location (Pearson's chi-square test)							
Home without service	48 (32.9)	0 (0)	4 (19.0)	.002	.001	1.0	.12
Home with service	51 (34.9)	10 (35.7)	8 (38.1)				
Institution	47 (32.2)	18 (64.3)	9 (42.9)				

NIHSS: National Institutes of Health Stroke Scale; CBS: Catherine Bergego Scale; mRS: modified Rankin Scale.
[a]Fisher's exact test if not otherwise mentioned; difference on Hodges–Lehmann-estimate for median difference. The Bonferroni correction was used in pairwise comparisons.

variables with length of stay as an offset variable. Of the variables with a significant or close to significant ($p<.15$) bivariate association with the number of incidents, eight explicative factors were chosen to be included in the final multivariate analysis with length of stay as an offset variable (Table 3). Admission and discharge FIM (total and motor), mRS and the ICF minimal generic data set sum correlated strongly ($\geq$0.80). FIM scores were excluded as they were included in the calculation of FIM effectiveness. Most fallers and non-fallers had neglect (Table 5); the fallers had on average more severe neglect, but the non-fallers had a wide range with scores at both ends of the continuum of neglect severity. Using either presence (p=.25) or severity ($p = 1.0$) of neglect produced the same final result in multivariate analysis. Presence of paresis and side of paresis correlated strongly; side of paresis and right and left hemispheric stroke were excluded because they overlap with stroke localisation.

Discussion

Fallers had mostly intermediate level of impairment and disability assessed with several measures (NIHSS, FIM, mRS and the ICF minimal generic data set). Rehabilitants most prone to falls and near falls were those needing assistance in transfers and those becoming walkers. The onetime fallers were most disabled at admission and discharge and they were most often institutionalised; nevertheless, they achieved the same overall functional and motor improvement as the non-fallers, however, after significantly longer inpatient rehabilitation. The repeat fallers, who had the longest rehabilitation in-stay, achieved equal functional ability as the non-fallers having faster motor gain and the greatest overall functional improvement compared to the other two subgroups. When taking the length of rehabilitation in-stay into consideration, shorter time from stroke onset, haemorrhagic stroke, right or left hemispheric stroke, presence of paresis, left-sided paresis, presence and severity of neglect (CBS), a history of myocardial infarction, number of comorbidities and high and fast motor gain were related to the number of incidents. Of them, right hemispheric stroke, a history of myocardial infarction, and shorter time after stroke onset were independent predictors for the number of incidents.

The incidence of falls and near falls was 14.8/1000 patient days, and of the actual falls 9.3/1000 patient days with decreasing occurrence during the three years investigated. Of the actual falls 21.6% were injurious with no serious consequences. These figures are in agreement with previous findings, the incidence varying between 2.8 and 28.5/1000 patient days and the occurrence of mostly minor injuries between 8 and 29% of falls [4,5,9,11,12,58,59] or even higher [3]. The special feature of including near falls in this study was based on the fact that they represented major disequilibrium events that would have led to actual falling if not prevented instead of just a feeling of 'going to fall' [60,61] or a slip, trip or perturbation of balance like in previous literature [62]. Near falls have been found to occur even more frequently than actual falls [63], in the current study, however, they accounted for 37% of all incidents. Our findings are in agreement with previous research, where most incidents happened during daytime in a patient room or in a toilet and while transferring [3,4,7,8,10,58,64,65]. It has been estimated that in subacute inpatient stroke rehabilitation the most probable FIM transfer score at the time of fall would be as low as 2–3 [7], which is in line with our finding. FIM transfer domain has been used to identify fall prone individuals also in community dwelling stroke survivors [66], and in geriatric rehabilitants [67,68]. Our findings support previous research showing that falls are most common in subacute stroke patients with difficulties in transfers [5,7,8,69,70], those becoming walkers [9], those using walking aids [71] and those changing walking ancillary during follow-up. Our finding of all fallers needing assistance in stairs is in line with previous studies in acute inpatient rehabilitation [70] and in community-dwelling elderly women [72], where inability to walk in stairs predicted falls. Part of the incidents in our population occurred while reaching. Previously, functional reach ability has been found to be associated with balance and fall risk in chronic phase [73,74].

Our finding of a nonlinear relationship between impairment or disability and incidents is in agreement with some previous studies using FIM [7,59,75,76]. The non-fallers had a wider range of FIM total and locomotion scores reaching to both ends of the scale, while none of the fallers had extreme scores showing the highest independence or highest dependence. Falls were most common in rehabilitants (ambulatory or sedentary or both) with admission FIM locomotion score from 2 to 5. The same nonlinear finding has been revealed in a large population of geriatric in-patients where those with FIM score 5 in locomotion were found to have most falls; falls could not be predicted with a FIM score and it was suspected that other functional tools besides FIM might also show the same nonlinearity [68]. In the present population, mRS and the ICF minimal generic data set with strong activity/mobility weighting showed the same pattern of occurrence of incidents mostly in the midrange. In a recent study in community dwelling post-stroke patients, a similar inverted U-shaped relationship between functional status rated with mRS and fall risk was observed [77].

Data on the correlation of NIHSS score to falls in subacute inpatient stroke rehabilitation is negligible. In the present study, the relationship between NIHSS score and incidents can be compared to a previous study reporting an association between a greater admission neurological deficit assessed with Scandinavian Stroke Scale and falls during rehabilitation [19]. Other studies have been conducted in community-dwelling populations; in a small population, greater stroke severity (NIHSS $\geq$4) was shown to be associated with higher fall risk [21], but in another study the opposite was found [10]. In yet another community study, the current NIHSS score was not associated with falls in stroke survivors who walked independently [78]. These results are not directly comparable to our population including both ambulatory and sedentary stroke inpatients in subacute stage. The association we found between admission NIHSS score (moderate to severe) and incidents shows a similar nonlinear pattern of relationship: the fallers did not have extreme scores in NIHSS, either. Even if the 24 h NIHSS is used to predict functional outcome in acute stroke [79], it was not capable of predicting future falls in this subacute stroke rehabilitant population. Irrespective of the baseline situation, as time passes the change in neurological and functional status and the different predicting tools applied make straight comparisons of falls in acute, subacute and chronic stroke unreasonable [14].

In the present study, the onetime and repeat fallers were on average more impaired and disabled than the non-fallers at admission (FIM, NIHSS); at discharge; however, only the onetime fallers were more disabled than the others (FIM, mRS, the ICF minimal generic data set). Many previous studies have also shown an association between falls in acute [80] and subacute stroke rehabilitation [6,7,70,75,76,81] and high dependence [58], low FIM score or moderate to severe disability assessed with Barthel index [8,19,82]. In the light of our results, functional improvement (FIM effectiveness) of the fallers was not worse compared to the non-fallers. The onetime fallers improved with the same rate (FIM efficiency) as the non-fallers, but as their initial motor impairment and disability was worse, they needed longer rehabilitation in-stay. The repeat fallers showed the greatest improvement reaching a clinically significant difference of 22 points on the FIM scale and erasing the initial difference in FIM dependence level between them and the non-fallers. As the non-fallers had the highest admission FIM scores and least possibility to improve (FIM ceiling effect), total corrected FIM effectiveness was calculated, and it confirmed that the repeat fallers improved more than the other two subgroups. The exquisite finding in this study is that the repeat fallers had not only the greatest improvement but also faster recovery of functioning than the non-fallers measured with motor FIM (efficiency), especially in the items walking, transfers, stairs, dressing and toileting. Previously, impaired ADL functioning has been considered the most consistent risk factor for falls, but ADL scores that most importantly have been associated with higher fall rates have not been distinguished [3]. A recent meta-analysis concluded that mobility problems and assisted self-care are related to falls also in chronic phase [83].

Age or gender, location or type of stroke have usually not been associated with falls [3,4,10], but variations have occurred in different populations [8,81,84–87]. In the present study, the repeat fallers were younger and more educated than the onetime fallers. The difference in years of education may be explained by the age difference between the subgroups, but interestingly multiple fallers were more educated also in another study [65]. The highest proportion of rehabilitants with intracerebral haemorrhage, right hemispheric stroke and left-sided hemiparesis were found in onetime fallers, while subarachnoid haemorrhage was most common in non-fallers. The distribution of fallers was highest among those with moderate leg paresis on admission. Previously in chronic phase, leg paresis has been shown to influence balance control and falls [64,88]. In the present study, both paresis and hemispheric stroke on either side were associated with the number of incidents, of them right hemispheric stroke independently predicted the number of incidents. Right brain damage [70,87] and left body-side affection [59] have also previously been found to be associated with higher odds of falling, possible explanations being the frequent coincidence of hemi-spatial neglect found to be associated with falls [4,29,58,86,89] and anosognosia for the consequences of stroke [90] leading to hazard situations. In the present population, 92% of the fallers but also as many as 64% of the non-fallers had neglect. Both the presence and severity of neglect were associated with the number of incidents, moderate neglect most significantly. The patient with the highest CBS score was a non-faller; the patient had a very severe stroke and paresis and was non-ambulatory and mostly bedridden, which narrowed down the risk of falling. Left hemispheric stroke [85], aphasia [82], apraxia and cognitive deficits [6] have been associated with falls in some previous studies while in the present population no between-group differences were found in cognitive FIM or the presence of apraxia or aphasia. The onetime fallers had higher Charlson index and more often comorbidities, cardiovascular disease and a history of myocardial infarction than the other two subgroups; of them myocardial infarction was found to be an independent predictor for the number of incidents. A history of myocardial infarction has also previously been found to predict falls in a population of acute stroke patients [91], but medication-related falls have been surprisingly uncommon in subacute stroke rehabilitation [58].

In contrary with a previous study [8], we found shorter time from stroke onset to be an independent predictor for the number of incidents during rehabilitation in-stay. The fallers were found to stay longer in rehabilitation than the non-fallers, the repeat fallers longest. Longer length of hospitalisation has also previously been associated with falls in subacute rehabilitation [5,59,81,86], and in acute care [91]. In line with previous studies, most incidents and especially the first events occurred within the first two weeks of stay [3,9]. As the repeat fallers tended to have their incidents earlier than the onetime fallers and their second incident was well within the time frame of the average length of stay of the onetime fallers, repeated incidents cannot be explained with longer rehabilitation only. Instead, explanations to multiple events must be sought elsewhere. Previous findings of the association between functional status and multiple falls have been contradictory [6,19,20,92]. In our population, the repeat fallers had the greatest and fastest change in functioning leading to significantly lower disability by discharge compared to the onetime fallers, which could explain some of the previous inconsistencies. We cannot entirely explain why the repeat fallers had the highest functional improvement; it is possible that they were most actively practicing their new skills and that they needed a longer rehabilitation to gain adequate and safe functioning before home discharge, but our study design does not answer this hypothesis. In our population, high motor improvement was found to be related to the number of incidents, but when taking the length of stay into account, it was not an independent predictor. Previously, high fall risk was found when activity was increasing fast [7]. Obviously, higher activity levels and e.g.

reducing wheelchair use increase the chance of incidents. On the other hand, exercises have been found to reduce fall rate, but not the number of people falling post stroke [37]. In a previous case-control study concentrating on rehabilitation outcomes in fallers, falls were not found to impact functional status or discharge destination but it was concluded that they may have contributed to a longer rehabilitation in-stay among fallers [5]. Nevertheless, in the community falls can have a negative influence on recovery [93].

Limitations to this study include a relatively short follow-up time on the rehabilitation ward and the reality that several factors influence the length of rehabilitation in-stay. The cross-sectional nature of our study design does not allow confirmation of causal relationships of disability, i.e. whether they are based on the disease itself or its secondary consequences. The number of patients was limited, even if adequate for the purpose of the study. The data were executed in a single university hospital with a selected population and may not be representative of all stroke survivors. However, fall risk factors differ according to admission and discharge criteria and other policy factors, rehabilitation programs and restrictions, environmental solutions, etc. Thus, every facility should investigate the emphasis of various fall risk factors prevailing in that particular unit. Since the study was conducted in subacute stage, the results are not directly generalisable to acute or chronic phases of stroke. In addition, assessments were not made at the time of the incidents, but scoring with different measures were executed at conventional time points. Also, data collection and analysing methods influence the results; when comparing our results with other studies, this kind of prospective study during rehabilitation in-stay with a wide range of recording specialists enables use of many validated measurements, and contrary to retrospective studies based on medical records or patient recall, recording also the number of falls per person and near falls is possible. Accordingly, the strengths of the study are its consecutive enrolment and prospective nature with careful reporting of all incidents and their exact description by an experienced professional. In the future, larger studies are recommended to investigate fall rate and different severities of incidents, falls and near falls separately. Studies should be conducted in different populations to capture the typical and specific features and characteristics of the type of facility in question.

Conclusions

This study compares clinical and functional characteristics in subacute stroke rehabilitants with no, one or repeated falls or near falls (considered as falls, which were prevented) using a unique set of the most preferred measures of stroke outcome research, NIHSS, FIM, mRS and in addition the ICF minimal generic data set. It also increases the previously scarce and contradictory knowledge on the impact of falls and multiple falls on functional progress during inpatient rehabilitation post stroke. The fallers were found to have mostly intermediate level of impairment and disability. The onetime fallers were most disabled at admission and discharge and they were most often institutionalised; nevertheless, they achieved the same overall functional and motor improvement as the non-fallers, however, after significantly longer inpatient rehabilitation. The repeat fallers, who had the longest rehabilitation in-stay, obtained equal functional ability as the non-fallers having faster motor gain and the greatest overall functional improvement compared to the other two subgroups. In addition, a multitude of clinical factors potentially predicting the number of incidents were investigated. When taking the length of rehabilitation in-stay into consideration, right hemispheric stroke, a history of myocardial infarction, and shorter time from stroke onset were found to be independent predictors for the number of incidents.

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Disclosure statement

The authors report no conflict of interest.

Author contributions

STT, SH and MK led the design of the study and performed the statistical analyses. TN assessed all the patients and rated the CBS score. All authors were involved in the drafting of the manuscript.

ORCID

Sinikka Tarvonen-Schröder http://orcid.org/0000-0002-2314-7166

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